

NASA Technical Paper 1026

**Results of Analyses Performed
on Basalt Adjacent to Penetrators
Emplaced Into Volcanic Rock
at Amboy, California, April 1976**

**M. Blanchard, T. Bunch, A. Davis,
H. Shade, J. Erlichman, and G. Polkowski**

SEPTEMBER 1977

**CASE FILE
COPY**

NASA

NASA Technical Paper 1026

Results of Analyses Performed on Basalt Adjacent to Penetrators Emplaced Into Volcanic Rock at Amboy, California, April 1976

M. Blanchard and T. Bunch
Ames Research Center
Moffett Field, California

A. Davis
San Jose State University
San Jose, California

H. Shade, J. Erlichman,
and G. Polkowski
LFE Corporation
Richmond, California



National Aeronautics
and Space Administration

**Scientific and Technical
Information Office**

1977

RESULTS OF ANALYSES PERFORMED ON BASALT ADJACENT TO PENETRATORS

EMPLACED INTO VOLCANIC ROCK AT AMBOY, CALIFORNIA, APRIL 1976

M. Blanchard, T. Bunch, A. Davis,* H. Shade,** J. Erlichman,** and G. Polkowski**

Ames Research Center

SUMMARY

During 1976, four penetrators were dropped on a test site at Amboy, California. The Amboy site was selected because it simulated penetration into basalt flows on the Martian surface. This report describes the physical and chemical modifications found in the basalt after the penetrators' impact.

Laboratory analyses show that mineralogical and elemental changes are produced in the powdered and crushed basalt immediately surrounding the penetrator. Optical microscopy studies of material next to the skin of the penetrator revealed a layer, 0–2-mm thick, of glass and abraded iron alloy mixed with fractured mineral grains of basalt. Elemental analysis of the 0–2-mm layer revealed increased concentrations of Fe, Cr, Ni, Mo, and Mn, and reduced concentrations of Mg, Al, Si, and Ca. The Fe, Cr, Ni, and Mo were in fragments abraded from the penetrator. Mineralogical changes occurring in the basalt sediment next to the penetrator include the introduction of micron-size grains of α -iron, magnetite, and hematite. The newly formed silicate minerals include metastable phases of silica (tridymite and cristobalite). An increased concentration of Fe, Cr, Ni, and Mo occurred in the 2-mm to 1-cm layer for penetrator no. 1, which impacted at the highest velocity. No elemental concentration increase was noted for penetrators nos. 2 and 3 in the 2-mm to 1-cm layer.

In summary, contaminants introduced by the penetrator occur up to 1 cm away from the penetrator's skin. Although volatile elements do migrate and new minerals are formed during the destruction of host minerals in the crushed rock, no changes were observed beyond the 1-cm distance.

INTRODUCTION

During 1976, a field-test program (refs. 1 and 2) was conducted at terrestrial analog sites to represent anticipated Martian materials in which the penetrator would penetrate to maximum and minimum depths. Maximum penetration occurred at McCook, Nebraska (ref. 3); minimum penetration occurred at Amboy, California. The Amboy site was selected because it simulated penetration into layered basalt flows on the Martian surface.

*Geology Department, San Jose State University, San Jose, Calif. 95132.

**LFE Corporation, Richmond, Calif. 94804.

This report describes the following results of the Amboy field tests: (1) the physical and chemical alteration of the basalt caused by the impacting penetrator, and (2) the amount of contamination introduced to the basalt by the penetrator during impact.

The Amboy site was deemed suitable based on field observations (ref. 4) and laboratory studies of basalt samples (ref. 5) from the site. The Amboy lava field is located 4.8 km west of the town of Amboy and covers an area of approximately 70 km². Amboy Crater, located in the northeast portion of the lava field, rises about 76 m above the surrounding lava flows. Located approximately 2000 m northeast of the crater is the relatively smooth plateau used as the drop site (fig. 1).

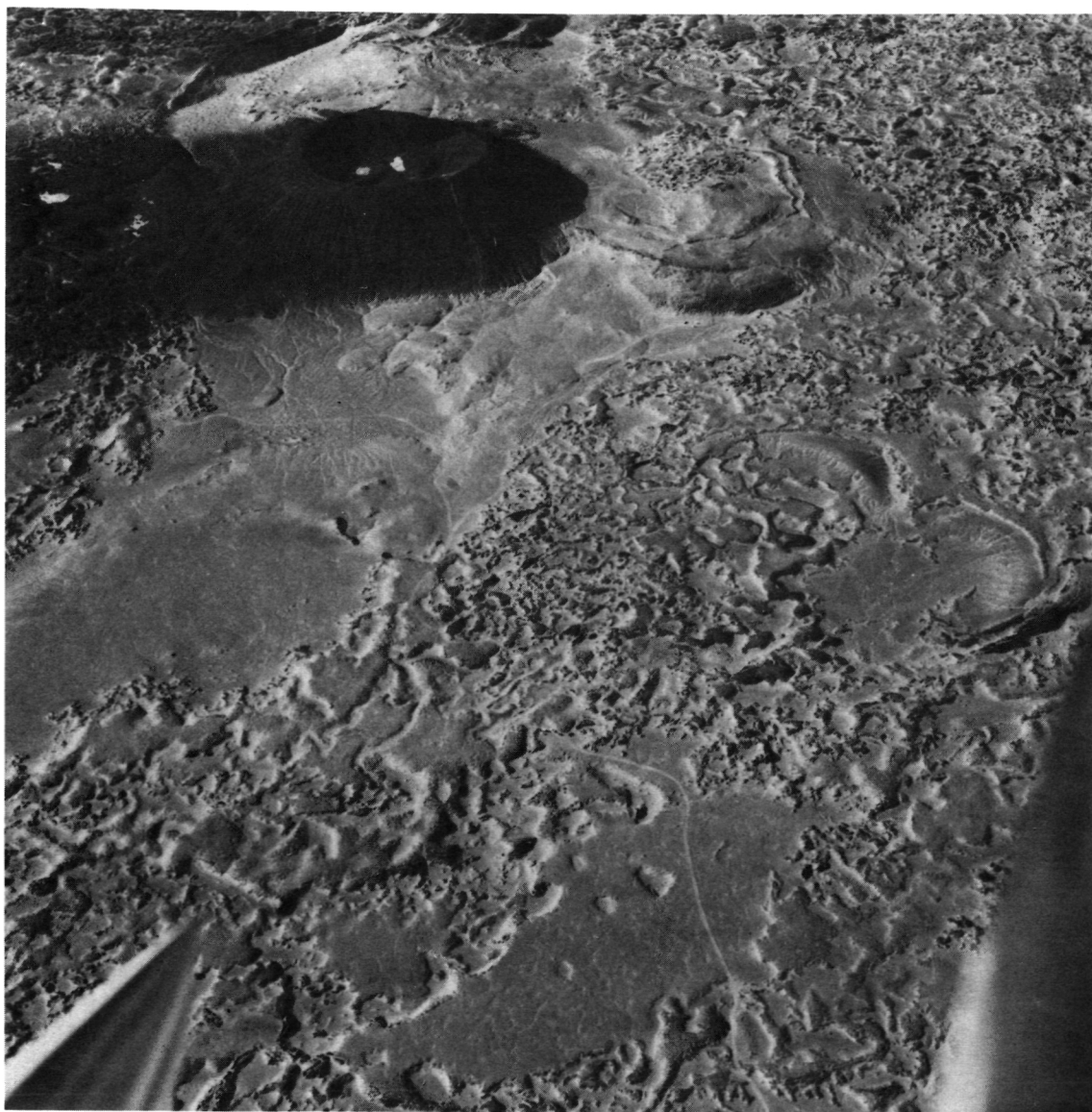


Figure 1.— Oblique aerial view of Amboy Crater and surrounding lava field. Jeep track at bottom of picture crosses the plateau used as the test site. (Photo courtesy of R. Greeley, University of Santa Clara.)

The authors acknowledge suggestions by T. Canning, R. Jackson, and R. Reynolds of Ames Research Center and thank R. Clayton at Ames for the excellent photomicrography. E. Reece of Sandia Corporation was in charge of the penetrator drop activities and subsequent penetrator removal. Quantitative X-ray fluorescence analyses were conducted by G. Cunningham, University of Oregon, Eugene. Motivation for the initial effort was provided by Dr. W. Quaide, former Planetary Science Applications Branch Chief, now at NASA headquarters. Finally, we had several helpful discussions with Dr. J. Fruchter, Batelle-Pacific Northwest Laboratories, Richland, Washington, geochemist on the Ad Hoc Surface Penetrator Science Committee chaired by Dr. J. Westphal, California Institute of Technology.

PROCEDURES

The field-test procedures involved dropping four full scale penetrators from a fixed-wing aircraft (fig. 2) into a basaltic lava plateau. Release altitudes, impact velocities, at-rest angles and penetration depths are listed in table 1. Penetrator no. 1 impacted at the highest velocity, 213 m/sec, penetrating four layers of lava flows and completely embedding itself in the basalt (fig. 3). Penetrator's nos. 2, 3, and 4 impacted at a velocity of 152 m/sec. The overburden of alluvium varied between 28 and 52 cm for penetrators nos. 1, 2, and 3. Penetrator no. 4 was dropped in an area containing several meters of alluvium and penetrated no basalt.

Field observations indicate the basalt fractured radially to accommodate the emplaced penetrator (fig. 4). A zone of crushed basalt fragments and powder 1–2 cm thick surrounded the penetrators emplaced in basalt. Some of this powder was ejected out of the hole and onto the surface of the



Figure 2.— A penetrator and two smoke bombs mounted under wing of aircraft before drop tests.

TABLE 1.— RELEASE AND IMPACT DATA AT TEST SITE, AMBOY,
CALIFORNIA APRIL 1976

Sandia drop sequence	Release altitude, m	Approximate velocity at impact, m/s	At-rest angle	Penetration depth, cm ^a		
				Alluvium	Basalt	Total
1	2590	213	7°	28	92	120
2	1980	152	14°	52	40	92
3	1980	152	14.5°	34	50	84
4	1980	152	17°	180	0	180

^aLaboratory measurements



Figure 3.— Penetrator no. 1, emplaced with most of the fractured basalt removed exposing nearly one full length side of vehicle. The 1-cm layer of powdered basalt has already been removed.

surrounding alluvial overburden (fig. 5). Some pitch and yaw displacement of the penetrators during emplacement was evident by the 7°–17° variation from the vertical for the at-rest positions (fig. 6). This displacement was probably a response to local changes (e.g., voids) in the subsurface rock or variable wind conditions at the time of impact. The newly formed impact crater and subsequent surface modification are shown in figures 5 and 6.

Recovery of the penetrators was as follows:

1. A backhoe, air hose, and shovel were used to remove the 30–60-cm thick alluvial overburden and expose the actual basalt surface.



Figure 4.— Radial fractures were produced by the penetrator during emplacement in the basalt; they were revealed when the alluvial overburden was removed.



Figure 5.— Penetrator no. 1 in initial at-rest position showing basalt fragments and powder ejected from hole onto the crater surface. Some of the ejected fragments are marked with a circle and arrow.



Figure 6.— Penetrator no. 3 in initial at-rest position of 14.5° inclination showing typical crater in alluvium.

2. The fractured basalt blocks were removed using a jackhammer as the principal tool. One full-length side of each penetrator was left exposed (fig. 3). Each fractured basalt block was carefully removed by hand to prevent falling debris from contaminating the 1–2 cm thick layer of powdered basalt adjacent to the penetrator's skin.

3. Samples were removed from the powdered zone (1–2-cm thick) surrounding the penetrator and stored in containers. Any small pieces of basalt or loose material showing signs of alteration were also recovered.

4. The penetrator was removed from the basalt by loosening it with a pry bar and lifting it by hand from the basalt. Care was taken to retain the adhering clumps of crushed basalt on the penetrator's skin (fig. 7).

5. Additional samples from the layer of powder (1–2-cm thick) were removed from the cast remaining in the crushed basalt (fig. 8) and stored in containers.

6. The penetrators were packaged in soft polyurethane foam and covered with plastic for transportation to Ames Research Center for laboratory studies.

Analytical studies performed on the skin of the penetrators and the surrounding powdered basalt included: optical microscopy, scanning electron microscopy, electron microprobe, X-ray diffraction and X-ray fluorescence.

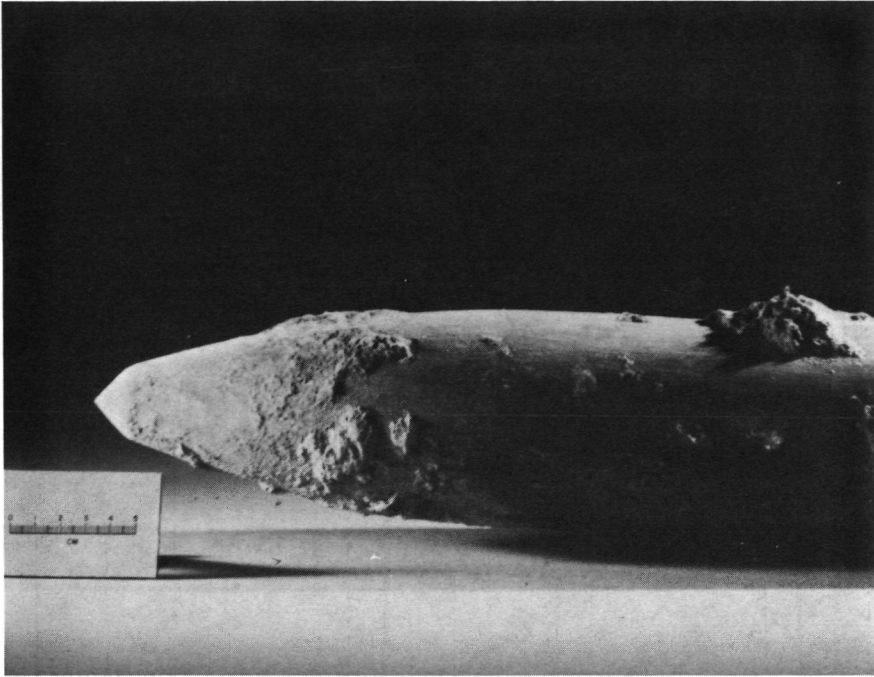


Figure 7.— Clumps of crushed basalt adhering to forward section of nose on penetrator no. 1.



Figure 8.— Cast of one-half of full-length penetrator left in crushed basalt after removal of vehicle. The powdered layer has not yet been removed. The scale coin is approximately 2.5 cm in diameter.

RESULTS

Size distribution studies (fig. 9) of fragmented and powdered basalt from penetrators nos. 1, 2, and 3 show a significant decrease in the particulate material smaller than 30 μm in size. This break in the size distribution corresponds with the predominant grain size of the basalt matrix, indicating that on entry most of the penetrator's crushing action produced breaking and fracturing along existing grain boundaries.

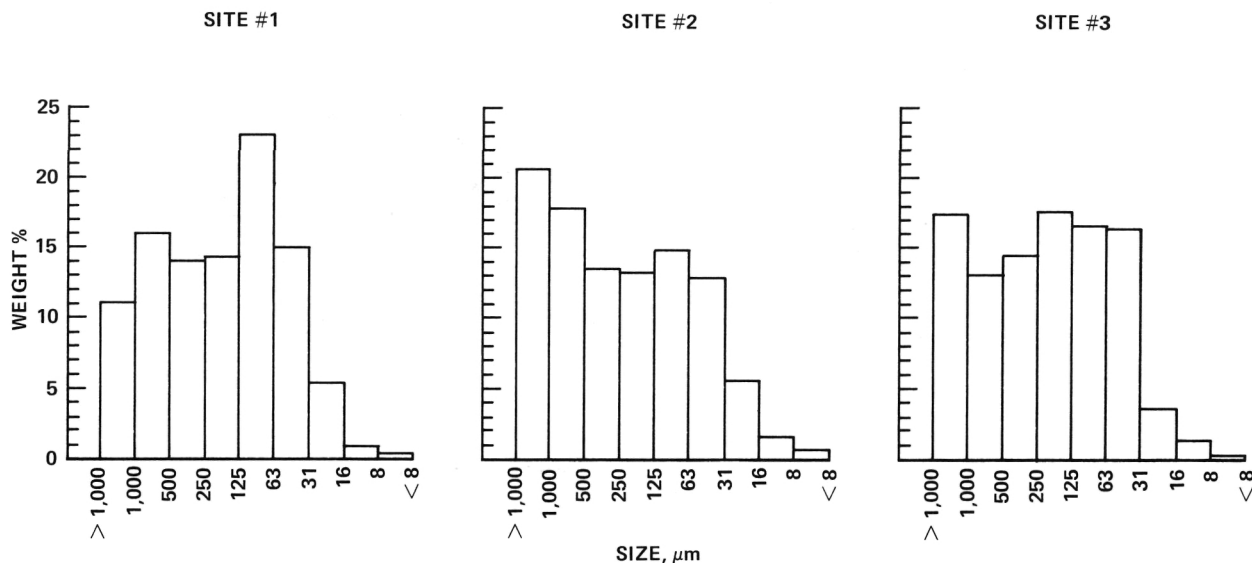


Figure 9.— Size distribution of comminuted basalt at impact sites 1, 2, and 3. Size distribution data was determined from $\approx 1\text{-cm}$ thick samples located 10 cm aft of penetrator nose.

Optical microscopy studies of the host rock showed it to consist mostly of plagioclase, pyroxene, and olivine (table 2 and fig. 10). The altered material next to the penetrator's skin is characterized by a layer 0–2-mm thick of dark colored glass mixed with micron-to-millimeter size grains of abraded iron alloy and fractured mineral grains from the basalt (fig. 11). A layer of abraded iron approximately 100 μm thick sometimes forms next to the penetrator's skin instead of

TABLE 2.— MINERALS IDENTIFIED BY OPTICAL MICROSCOPY
IN UNDISTURBED BASALT AT IMPACT SITE,
AMBOY, CALIFORNIA

Mineral names	Estimated abundance, %
Plagioclase (labradorite, An_{60})	50
Pyroxene (augite/pigeonite)	32
Olivine (Fo_{70-80})	10
Ilmenite and magnetite	5
Alteration products (iddingsite and limonite)	3
Hornblende	tr
	100

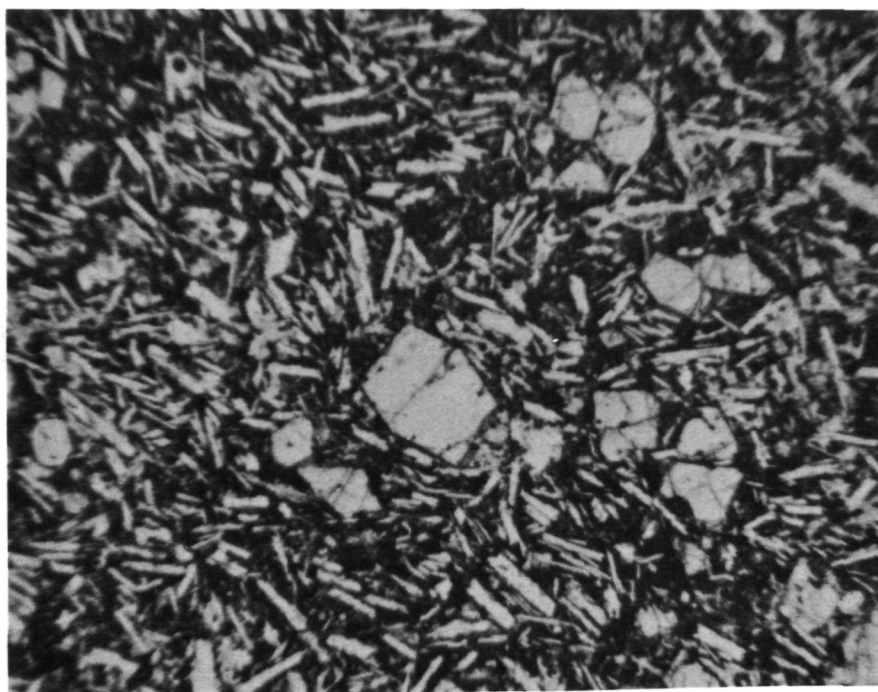


Figure 10.— Petrographic thin-section of undisturbed basalt in transmitted light. Small transparent lath-like crystals are plagioclase; larger transparent equant grains are olivine and augite. Small opaque grains are ilmenite.

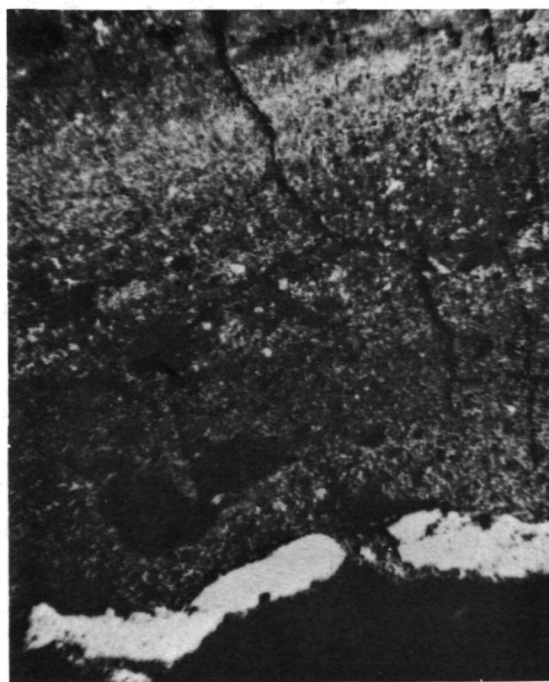


Figure 11.— Photomicrograph of polished section of basalt in the 0-1 mm layer parallel to the penetrator skin. Taken with reflected light (abraded iron particles are white and glass is gray).

the glass. The remainder of the iron particles are distributed throughout the 0–2-mm zone. Striations prominently mark the face of the glassy-iron-rich material (fig. 12). These striations are impressions made by the machine marks remaining on the surface of the penetrator. A second set of striations commonly occurs perpendicular to the first set. Striations in the second set are casts of grooves which were produced by the forward movement of the penetrator as it moved through the soil.

Comparison of bulk elemental composition between undisturbed and modified host rock near the penetrator showed changes in most elements (table 3). The surface of the glassy material was enriched significantly in Fe (up to 27%), Cr (to 0.3%), Ni (to 0.2%), and Mo (to 0.2%). This enrichment was caused by the introduction of elements from the penetrator D6AC alloy (table 4). Elements noticeably depleted were aluminum (to 6%) and Si (to 19%). Bulk analysis on samples from the 0–2-mm glassy layer revealed increased concentrations of Fe, Cr, Ni, Mo, and Mn, and reduced concentrations of Mg, Al, Si, and Ca. Bulk analysis on samples from the 2-mm to 1-cm layer showed concentrations of Fe, Cr, Ni, and Mo higher for penetrator no. 1 than the natural level in the undisturbed basalt. The concentration of these same elements in the 2-mm to 1-cm layer for penetrators nos. 2 and 3 is near the undisturbed level for basalt. Penetrator no. 1 impacted at a greater velocity (213 m/sec) than penetrators nos. 2 and 3 (152 m/sec), which may account for the greater mixing and outward migration of material abraded from penetrator no. 1. In most cases, the concentrations of Fe, Cr, Ni, and Mo returned to their normal level in the powder within 1 cm of the penetrator. The iron content in the glassy material next to the penetrator ranged from 12 to 27%. Scanning electron microscopy studies showed the glass to have vesicles which demonstrated

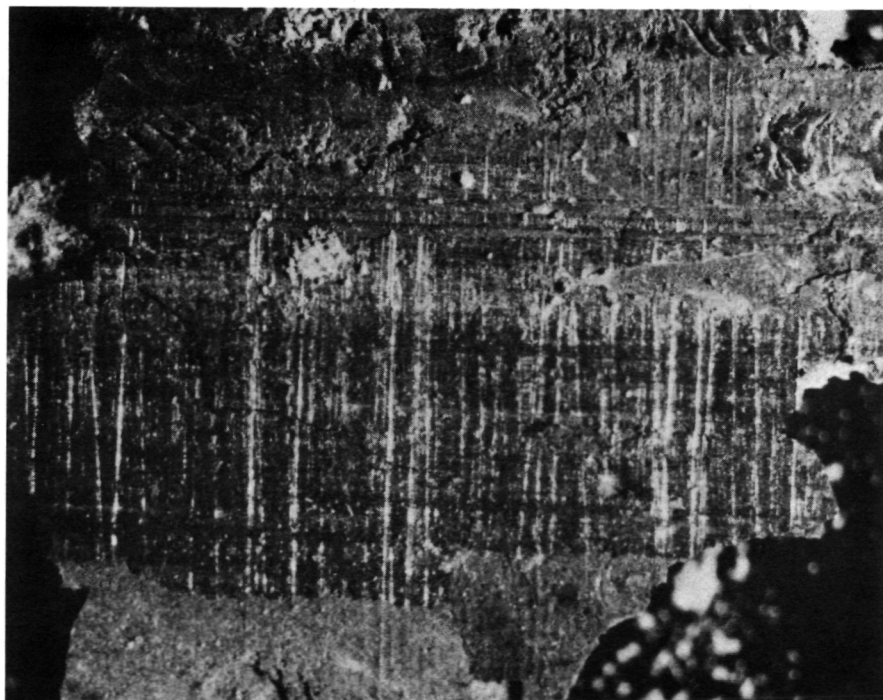


Figure 12.— Photomicrograph of the surface of a powdered fragment from the iron-rich glassy layer showing striations.

TABLE 3.— ELEMENTAL COMPOSITION (WEIGHT %) OF UNDISTURBED AND COMMUNITED BASALT SAMPLES

Element	Undisturbed basalt (bulk) ^a	Undisturbed alluvium (bulk) ^a	Cominuted basalt												Individual grains analyzed with electron microprobe
			Loose powder 1-2 cm from skin (bulk) ^a			Cohesive powder 1 cm- 2 mm from skin (bulk) ^a			Powder adhering to skin 0-2 mm (bulk) ^a			Penetrators	Penetrators	Penetrators	
			1	2	3	1	2	3	1	2	3				
Na	2.21	2.19	2.63	2.21	2.40	2.37	2.80	2.56	2.17	2.14	2.29				2.1 – 2.6
Mg	4.75	1.00	4.24	4.37	4.16	4.54	4.41	4.09	3.31	3.16	3.39				not determined
Al	8.42	8.29	8.00	8.21	8.28	8.43	8.47	8.17	6.71	6.55	7.24				6.1 – 7.4
Si	22.50	29.11	22.30	21.95	22.45	22.47	22.43	22.38	18.65	17.72	19.43				19.0 – 22.1
P	.24	.08	.22	.24	.21	.25	.23	.22	.19	.17	.20				not determined
K	1.33	2.44	1.57	1.47	1.59	1.49	1.49	1.51	1.25	1.18	1.29				1.4 – 1.5
Ca	6.03	2.83	6.33	5.96	5.78	6.09	6.12	5.92	4.98	4.94	5.30				5.4 – 6.2
Ti	1.27	.52	1.10	1.20	1.11	1.30	1.23	1.13	.96	.95	1.06				not determined
Mn	.13	.07	.12	.12	.12	.14	.13	.12	.22	.25	.20				not determined
Fe	7.88	3.44	7.56	7.86	7.21	8.21	7.85	7.29	21.85	24.46	19.62				12.4 – 26.9
Cr	119 ppm	25 ppm	118 ppm	123 ppm	110 ppm	127 ppm	112 ppm	108 ppm	782 ppm	596 ppm	423 ppm				.1 – .3
Ni	128 ppm	21 ppm	112 ppm	132 ppm	114 ppm	152 ppm	116 ppm	113 ppm	602 ppm	454 ppm	372 ppm				.002 – .2
Mo	<15 ppm	<15 ppm	<15 ppm	37 ppm	<15 ppm	27 ppm	22 ppm	<15 ppm	1,494 ppm	1,400 ppm	745 ppm				.025 – .2

^a(bulk) — indicates bulk sample analysis performed by X-ray fluorescence.

TABLE 4.— ELEMENTAL COMPOSITION OF
PENETRATOR STEEL ALLOY

Elements	D6AC specifications ^a	Electron Microprobe analyses (weight %) penetrator interior
Fe	96.52–94.95	96.2
C	.45 – .50	
Si	.15 – .30	.2
P	.00– .10	.08
S	.00– .10	
V	.08– .15	.08
Cr	.90– 1.20	1.0
Mn	.60– .90	.7
Ni	.40– .70	.6
Mo	.90– 1.10	1.0
		<hr/> 99.86

^aSandia metallurgical report

gas escaped during the glass formation. Also, numerous micron-size iron alloy spherules were formed (fig. 13). The high concentration of iron in the glassy layer was a result of metal abraded from the penetrator and introduced into the powdered host rock. Significant increases in the glassy layer for Cr, Ni, and Mo can be accounted for in the same manner.

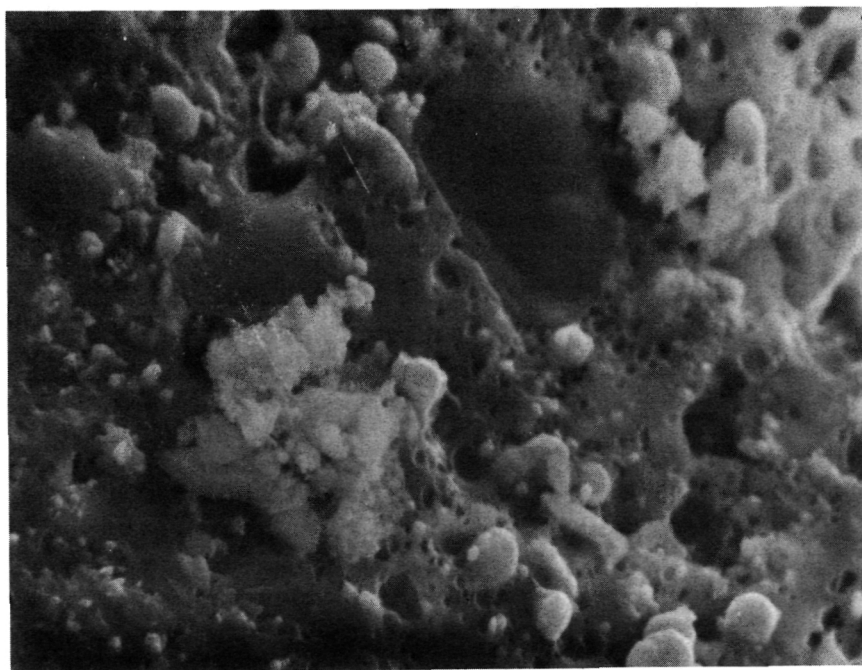


Figure 13.— Scanning electron microscope image of glass layer next to penetrator's skin. Note the glass matrix with vesicles. The numerous small spherical-shaped objects projecting out of the glass matrix are iron spherules containing: α iron, magnetite, and hematite. These spherules indicate the iron from the penetrator melted during abrasion.

The mineralogical changes occurring in the powdered rock next to the penetrator include both the introduction of new material and the formation of new phases (table 5). X-ray diffraction patterns of individual grains have identified tridymite, cristobalite, and an amorphous phase in addition to the host minerals in the basalt. Also identified were α iron (with traces of Cr, Ni, and Mo), magnetite, and hematite. Commonly these three phases occur together in the same particle.

TABLE 5.— MINERALS IDENTIFIED BY X-RAY DIFFRACTION IN
UNDISTURBED AND COMMINUTED BASALT SAMPLES

Mineral name	Undisturbed basalt	Powdered basalt adhering to penetrator's skin, 0-2 mm
Plagioclase (An_{60})	High	Moderate
Pyroxene (augite/pigeonite)	Moderate	Moderate
Olivine	Moderate	Moderate
α iron	Not detected	High
Hematite (α Fe_2O_3)	Not detected	Low
Magnetite (Fe_3O_4)	Trace	Low
Tridymite	Not detected	Trace
Cristobalite	Not detected	Trace

DISCUSSION

The temperature effects near the penetrator's skin (<2 mm) were recorded by both the occurrence of micron-sized iron spherules and the occurrence of glass. The existence of a melt phase is essential to produce α iron spherules containing a mixture of oxides (magnetite and hematite). Assuming that an equilibrium temperature-composition diagram can be applied, the minimum temperature required to produce a liquid iron oxide phase is above 1400° C (ref. 6). A melt phase is also necessary to produce glass from a rock of basaltic composition. The minimum temperature required to produce a glass phase for a melt of basaltic composition under dry conditions is approximately 1200° C (ref. 7). The extent to which moisture and transient shock pressures produced by the penetrator may have caused these changes to occur at lower temperatures is not known.

In reconstructing the sequence of events, it seems that metallic particles were abraded from the penetrator as it forced its way through the volcanic rock. During this action, the basalt became fragmented and crushed. A powder was formed during this activity principally by failure along grain boundaries of the basalt matrix. During this process, the penetrator skin became very hot and many of the abraded iron particles were melted and oxidized forming micron-size spherules. The basalt powder immediately adjacent to the penetrator's skin was melted. After penetrator movement ceased, the silicate melt cooled rapidly, forming a glass. Local variation in mineralogy and nonequilibrium conditions were responsible for enriching the melt in silica sufficiently to enable occasional tridymite and cristobalite crystals to form on cooling.

Although important changes in elemental and mineralogical content occurred within 1 cm of the penetrator's skin, the crushed material beyond 1 cm is virtually identical to the undisturbed basalt (table 6).

TABLE 6.— SUMMARY OF CHANGES IN BASALT AT PENETRATOR IMPACT SITES
AMBOY, CALIFORNIA. APRIL 1976

Distance away from penetrator	Material	Elemental changes		Mineralogical changes	
		Increase	Decrease	Introduced or newly formed	Depleted
0–2 mm	Glass, iron particles, and mineral grains	Fe, Cr, Ni, Mo, Mn	Mg, Al, Ca, Si, Ti(?)	α iron magnetite hematite tridymite cristobalite amorphous material	(?)
2 mm – 1 cm	Comminuted basalt	Fe, Cr, Ni, ^a Mo	None	(?)	(?)
1–2 cm	Comminuted basalt	None	None	None	None

^aPenetrator no. 1 only – no changes for penetrators no. 2 and no. 3

CONCLUSIONS

Field observations combined with laboratory analyses have demonstrated that mineralogical and elemental changes are produced in the basalt powder next to the penetrator. Contaminants introduced by the penetrator commonly occur as far away from the penetrator's skin as 1 cm (tables 3 and 6) and some new minerals are formed as the host minerals are crushed and melted. However, no changes were observed beyond this 1 cm boundary.

These results are similar to earlier findings (ref. 3) in that either a sample retrieval mechanism or a passive ramp and entrapment device on the penetrator's exterior is essential to collect unmodified basaltic material for the geochemistry and water-detection experiments.

Ames Research Center

National Aeronautics and Space Administration

Moffett Field, California 94035, June 24, 1977

REFERENCES

1. Blanchard, M. B.; Oberbeck, V. R.; Bunch, T. E.; Reynolds, R. T.; Canning, T. N.; and Jackson, R. W.: FY 1976 Progress Report on a Feasibility Study Evaluating the Use of Surface Penetrators for Planetary Exploration. NASA TM X-73,181, Nov. 1976, p. 280.
2. Ames Staff: Mars Surface Penetrator, System Description, Prepared for the Mars Science Working Group. NASA TM X-73,243, 1977.
3. Blanchard, M.; Bunch, T.; Davis, A.; Kyte, F.; Shade, H.; Erlichman, J.; and Polkowski, G.: Results of Analyses Performed on Soil Adjacent to Penetrators Emplaced into Sediments at McCook, Nebraska, NASA TN D-8500, Jan. 1976.
4. Greeley, R.; and Bunch, T. E.: Basalt Models for the Mars Penetrator Mission: Geology of the Amboy Lava Field, California. NASA TM X-73,125, Apr. 1976.
5. Bunch, T. E.; Quaide, W. E.; and Polkowski, G.: Initial Basalt Target Site Selection Evaluation for the Mars Penetrator Drop Test. NASA TM X-73,111, Nov. 1976.
6. Darken, L. S.; and Gurry, R. W.: Physical Chemistry of Metals. McGraw-Hill Book Co., 1953, pp. 350-359.
7. Turner, F. S.; and Verhoogen, J.: Igneous and Metamorphic Petrology. McGraw-Hill Book Co., 1960, pp. 154-155.

1. Report No. NASA TP -1026		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle RESULTS OF ANALYSES PERFORMED ON BASALT ADJACENT TO PENETRATORS EMPLACED INTO VOLCANIC ROCK AT AMBOY, CALIFORNIA, APRIL 1976				5. Report Date September 1977	
				6. Performing Organization Code	
7. Author(s) M. Blanchard, T. Bunch, A. Davis,* H. Shade,** J. Erlichman,** and G. Polkowski**				8. Performing Organization Report No. A-7078	
9. Performing Organization Name and Address Ames Research Center, Moffett Field, CA 94035,				10. Work Unit No. 186-68-76-06	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546				13. Type of Report and Period Covered Technical Paper	
				14. Sponsoring Agency Code	
15. Supplementary Notes *San Jose State University, San Jose, CA 95132 **LFE Corporation, Richmond, CA 94804					
16. Abstract During 1976, four penetrators were dropped on a test site at Amboy, California. The Amboy site was selected because it simulated penetration into basalt flows on the Martian surface. This report describes the physical and chemical modifications found in the basalt after the penetrators' impact. Laboratory analyses show that mineralogical and elemental changes are produced in the powdered and crushed basalt immediately surrounding the penetrator. Optical microscopy studies of material next to the skin of the penetrator revealed a layer, 0-2 mm thick, of glass and abraded iron alloy mixed with fractured mineral grains of basalt. Elemental analysis of the 0-2 mm layer revealed increased concentrations of Fe, Cr, Ni, Mo, and Mn, and reduced concentrations of Mg, Al, Si, and Ca. The Fe, Cr, Ni, and Mo were in fragments abraded from the penetrator. Mineralogical changes occurring in the basalt sediment next to the penetrator include the introduction of micron-size grains of α -iron, magnetite, and hematite. The newly formed silicate minerals include metastable phases of silica (tridymite and cristobalite). An increased concentration of Fe, Cr, Ni, and Mo occurred in the 2-mm to 1-cm layer of penetrator no. 1, which impacted at the highest velocity. No elemental concentration increase was noted for penetrators nos. 2 and 3 in the 2-mm to 1-cm layer. In summary, contaminants introduced by the penetrator occur up to 1 cm away from the penetrator's skin. Although volatile elements do migrate and new minerals are formed during the destruction of host minerals in the crushed rock, no changes were observed beyond the 1-cm distance.					
17. Key Words (Suggested by Author(s)) Penetrators Mars exploration Planetary missions			18. Distribution Statement Unlimited STAR Category - 88		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 16	
				22. Price* \$3.25	

*For sale by the National Technical Information Service, Springfield, Virginia 22161

National Aeronautics and
Space Administration

Washington, D.C.
20546

Official Business

Penalty for Private Use, \$300

SPECIAL FOURTH CLASS MAIL
BOOK

Postage and Fees Paid
National Aeronautics and
Space Administration
NASA-451



NASA

POSTMASTER: If Undeliverable (Section 158
Postal Manual) Do Not Return
